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No. 41

Pests of pastures

by

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ABSTRACT

The natural pasture of South Africa is probably the country's greatest agricultural asset. The termites and caterpillars that attack this valuable economic resource may be regarded as unique in the South African pest situation. These are indigenous insects that are regarded as pests of indigenous plants and offer magnificent scope for ecological investigation. The chemical control of these pests should be approached with great caution.

The pests of improved pastures range from the Collembola to the Coleoptera and include a number of exotic as well as indigenous species that attack such well known plants as lucerne and lupins.

INTRODUCTION

The natural pastures of South Africa, although of variable quality, have often been described as the country's greatest agricultural asset. It is probably correct to state that research into the maintenance and reclamation of natural veld is one of the most important functions of the Department of Agriculture. For these reasons, any insect that poses a threat to such a valuable economic resource, should be regarded in serious light.

Improved pastures in the higher rainfall regions as well as fodder production on various irrigation schemes also play a vital role in the livestock industry of South Africa.

A. *Pests of Natural Pastures*

(i) The harvester termite, Hodotermes mossambicus (Hagen) (Isoptera: Hodotermitidae)

The natural vegetation of the pastoral regions of South Africa consists of a large variety of grasses and shrubs. These plants serve as food for cattle and sheep as well as for the harvester termite. The rainfall over most of the inland areas is relatively low and unreliable and for this reason the plant production per unit area is of crucial importance to the graziers, especially during a drought. The termites compete with the grazing animals for food under local conditions where an absolute shortage of food probably occurs fairly regularly.

Distribution: H. mossambivus occurs all over South Africa except in those parts with an annual water surplus (Nel, 1968a). The insects are therefore absent from parts of the Eastern Transvaal as well as the greater part of Natal and the Eastern and Western Cape Province.

Pest status: The pests of natural pastures may be regarded as unique in the South African pest situation. They are indigenous insects that are regarded as pests of indigenous plants. This phenomenon probably indicates some measure of ecological disturbance.

When assessing the pest status of *H. mossambicus,* it is important to note that the natural vegetation of South Africa underwent tremendous changes during the last century and this process is still taking place. Macchia has replaced grassveld over vast areas. The main cause of this change is the injudicious use of the veld as grazing for domestic animals and the associated phenomena of rapid run-off, soil erosion, inferior vegetation and sparse plant cover. Harvester termites probably contribute to this process of veld deterioration and lowered carrying capacity and the problem is one of a realistic evaluation of their contribution to this process.

A survey was conducted in the Free State and Northern Cape to correlate termite damage and grazing practices (Nel, 1968b). Farmers on overgrazed and uneconomically small farms reported most termite damage and regarded the insects as a serious threat. The owners of well managed farms regarded the termites as unimportant to their farming operations. These, and other observations, pose the question: Should *H. mossambicus* be regarded as a "pest" of natural veld? This question has not been adequately answered, although the suggestions offered below go some way towards an answer.

Aspects of the ecology with a bearing on pest assessment and control

(a) *H. mossambicus* is a subterranean termite. Coaton (1958) gives a general account of the biology and habits of the insects. Hives are built at depths ranging from 1 to 6 m depending on the depth and water relations of the soil (Nel, 1969). The termites subsist on grass and other plant material carried underground by a special caste of pigmented workers through foraging holes on the soil surface. These holes are closed with soil plugs when not in use. "Soil dumps", consisting of loosely-packed soil particles, are thrown upon the surface. These dumps are not permanent structures and are quickly obliterated by rain. Reproduction and colony foundation are consistent with the usual isopteran pattern.

(b) A controversy has developed around the size of the area on the soil surface occupied by a single colony of *H. mossambicus.* Coaton (1958) states that these termites are multihived and that one colony can occupy an area of approximately 6,5 ha. Nel (1968c) employed the aggressive response of workers as a criterion of territorial behaviour and his estimate was approximately 0,01 ha per colony. Hartwig (personal communication) excavated a large number of hives and concluded that different hives are interconnected below the soil surface and therefore presumably "belong" to the same colony. These interconnected hives represented a large surface territory. The size of the "colony territory" and the number of colonies per unit area are of some importance when questions such as possible self-regulatory mechanisms and chemical control are considered.

(c) A colony consists of approximately 15 per cent pigmented workers, 1,5 per cent soldiers and 83,5 per cent unpigmented "larvae" (Hewitt, Nel & Conradie, 1969). The pigmented workers are able to undergo stationary moults and should not be regarded as terminal forms. The larvae tend the eggs, feed the hatchlings, reproductives, soldiers and pigmented workers and are responsible for transmitting

the caste-controlling pheromones throughout the colonies. The pigmented workers are the foragers (although they are sometimes accompanied on the surface by a few larvae and one or two soldiers) and seem to do most of the excavating. They also have a defensive function in which the soldiers participate, although the function of this last caste in the colony is still obscure (Nel, Hewitt, Smith & Smit, 1969). An interesting point is that the pigmented workers are unable to subsist on their own and can only do so in the presence of the larvae (Nel, Hewitt & Joubert, 1971).

(d) Most of the food material is harvested during the winter months when the veld is in a dormant condition. The termites prefer dry plant material to green and die if given only green plant material as food. They do, however, subsist on a mixture of dry and green material, but the greater the proportion of dry material the better they thrive (Nel, Hewitt & Joubert, 1971).

(e) After the annual swarming flight at the beginning of summer, termite activity decreases (Nel & Hewitt, 1969a). This is probably due to the fact that there are fewer mouths to feed and it is also possible that the numbers of workers and larvae decline during the summer months to form a relatively small nucleus which starts to grow again during autumn. Seen in this way, the spring swarming might be a population regulating process as far as individual colonies are concerned.

(f) Relatively large amounts of dry plant material are present on the veld during winter. This food can only be collected during the day time, as the winter nights on the Highveld are too cold for foraging. It is probably for this reason that *H. mossambicus* developed a special pigmented forager resistent to ultra violet radiation from the sun (Nel & Hewitt, 1969b).

(g) Termite infestations appear in the form of "patches". These may be small (0,1 ha) or big (8 ha). A termite patch is probably made up out of a large number of individual colonies. The number of colonies per patch is probably regulated by means of the aggressive behaviour of colonies (Nel, 1968c).

(h) Damage done by harvester termites fluctuates from year to year and from place to place. Relatively quick population build-ups and crashes seem to be characteristic of the species (Nel & Hewitt, 1969a, Nel, 1970).

Control: With the exception of small local areas, *H. mossambicus* seems to be unable to cause widespread permanent damage to natural vegetation (Nel, 1968b). During a winter when the termites are locally abundant, dry material (and often all dry material) is removed during the period May to August. Consequently, little or no roughage is left during September and October, months when stock feed is critically scarce.

Nel & Van Aswegen (1972) proposed a scheme whereby termite control may be integrated with a three camp grazing system as recommended for the Central Orange Free State. Camps that are required in spring are treated during the preceding winter. In this way one third of the farm is treated every year (Fig. 1.)

(ii) The Karoo harvester termite, Microhodotermes viator **Latreille (Isoptera: Hodotermitidae)**

Microhodotermes viator is confined to the Cape Province and roughly occurs south of an imaginary line drawn from Upington in the north-west to East London in the south-east. A general account of the biology of these termites may be found in Coaton, 1958.

The nest system of an *M. viator* colony consists of a single hive surrounded by numerous foraging chambers. The hive (nest) and the foraging chambers are connected by means of subterranean passages, a number of which terminate on the soil surface. The workers forage on the surface for plant material which they cut into pieces from 1 to 2,5 cm long. Soil dumps, similar to those of *H. mossambicus*, are frequently found. In some areas, especially to the south-east of Beaufort West, a single hard mound reaching a vertical height of one metre or more is situated directly over the hive. In many other areas no mound is built. The conspicuous mound makes it an easy task to locate and excavate the hive.

Pest status: According to Van Ark (1966), the economic importance of harvester terminates in karroid areas is greatly overrated and this author is of the opinion that the elimination of uneconomic farming units should probably solve the "termite problem" in these areas. In parts where the termites are of doubtful economic importance, short term resting (one or two years) should solve the problem. If it is in any way possible to restore the natural vegetation by grazing practices, this should for obvious reasons be preferred to insecticidal treatments.

(iii) The snouted harvester termite, Trinervitermes trinervoides **(Sjöstedt) (Isoptera: Termitidae)**

Sands (1965) states that *Trinervitermes trinervoides* seems to be the only species of *Trinervitermes* inhabiting the limits of subtropical and temperate South Africa. Numerous forms are recognised but it is not known whether these constitute "true allopatric subspecies, sections of one or more clines, or genetically heterogeneous variants of similar appearance induced by similar ecological conditions in different areas".

Coaton (1948) published a general account of the biology and habits of the snouted harvester. This species inhabits a cellular mound and the nest structure does not penetrate into the soil to any great depth. The termites live on dry grass which is carried underground and stored in the mound. Overgrazing tends to increase the number of mounds per unit area, but no explanation for this phenomenon has been put forward. Widespread mortality of nests has often been observed in the field.

Relatively little is known of the damage done to the veld by these termites and no critical study of their pest status has been made.

Chemical control is simple to carry out and relatively cheap.

PLANTPRODUKSIE EN TERMIETE/PLANT PRODUCTION AND TERMITES

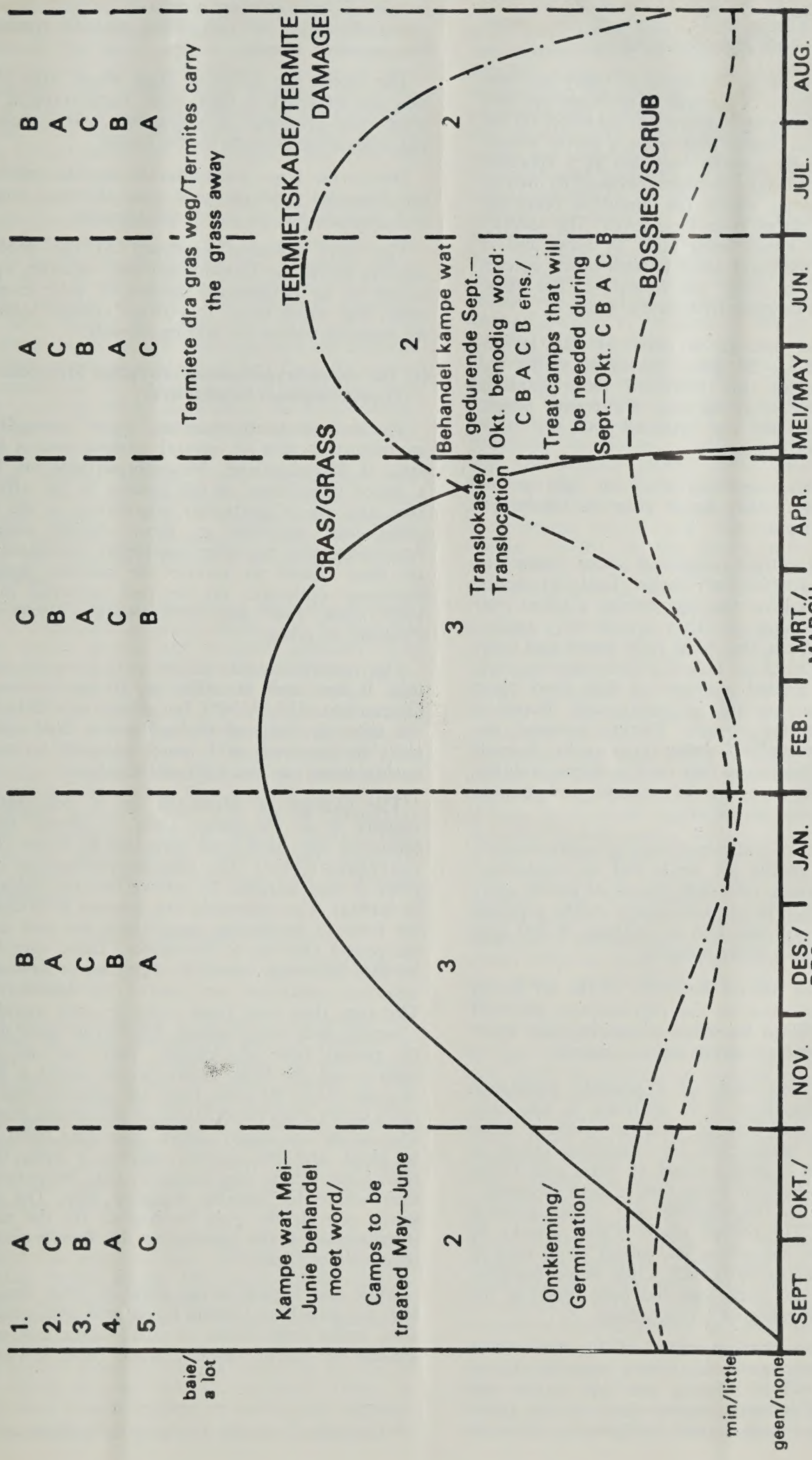

Fig. 1 Control of *H. Mossambicus* integrated with three camp grazing system
Fig. 1 *Beheer van* H. Mossambicus *in 'n driekampweidingstelsel*

(iv) The Karoo caterpillar, *Loxostege frustalis* Zeller (Lepidoptera: Pyralidae)

The damage done by this insect is mainly confined to the Karoo areas, although the insect occurs over the whole of Southern Africa.

Pest status: As far as is known, no study has been made of the amount of damage done to natural veld by this insect. Nothing is known of its effect on the physiology of the Karoo bush after a severe attack. *Loxostege frustalis* may be regarded as a sporadic pest. Severe outbreaks are often followed by two or three years during which the insect is relatively scarce or even absent from local areas. The severity of the damage varies from farm to farm and is determined by the plant cover as well as the species composition of the veld. The severity of the infestations seems to decrease from east to west.

Biology: The damage is done by the larvae. Although there are 20 plant species on which the larvae can subsist, the preferred food plant is "ankerkaroo" (*Pentzia incana*). Cultivated plants, such as lucerne, are not attacked and the same applies to natural grasses.

The newly laid eggs are white to light yellow but darken before they hatch after an incubation period of two days.

The larvae construct communal silken "tents" in karoo bushes in which they shelter, feed and moult. They sometimes leave the tent, leaving a silken trail behind them as they go. They are strongly gregarious, about 3,75 cm long when fully grown and from light green to black in colour. When mature, they enter the soil around the base of their food plant where a silken cocoon is constructed. Pupation takes place in the cocoon. During summer the larval stage is completed within three weeks. A small proportion of the larvae that mature during autumn may enter diapause in the cocoon and pupate approximately one year later.

The duration of the pupal stage is approximately 12 days. The moths are small and inconspicuous. They are brownish with light brown or cream spots on the forewings. In the laboratory, moths survived for about 20 days and laid an average of 200 eggs each when fed on a sugar solution.

Ecology: The relative humidity of the air seems to have an influence on the reproductive potential of the moths. When the relative humidity falls much below 60 per cent, the moths fail to oviposit.

Much has been made of a possible population regulatory mechanism in *L. frustalis*. It has been claimed that the females tend to oviposit more eggs on taller plants than on vegetation closer to the ground. In a mixed stand of grass and karoo bushes, this behaviour tends toward high mortality of hatchlings on unpalatable and taller growing grass species. The overall result is that attacks by *L. frustalis* are less severe in "mixed" veld than in a pure stand of karoo bushes. Little or no evidence in support of this hypothesis has been found in the field, but investigations are proceeding.

Control: Ten larval parasites of *L. sticticalis* (a related N. American species) were imported during the period 1942-48. During the late forties and early fifties, *Chelonus texanus* (one of the above 10 species) was mass-reared on *Ephestia kühniella* and liberated in the Karoo. It failed to become established but in the process of post liberation searching for this insect, a naturally occurring larval parasite, *C. curvimaculatus*, was discovered. Another potentially important indigenous parasitic species is *Macrocentrus maraisi*.

The moths are active at night when large numbers are attracted to light traps. Light-trapping has often been proposed as a feasible control measure and holds some promise for the future.

Due to the large areas affected and the relatively low financial yield per unit area, chemical control of *L. frustalis* may be ruled out at present.

The only practical approach to the problem appears to be the introduction and vigorous application of an enlightened system of veld management, the object being to provide enough food for the insect as well as the grazing animals.

(v) The mesembryanthemum caterpillar *Mesocelis* spp. (Lasiocampidae: Lepidoptera)

The mesembryanthemum or "vygie" caterpillar is an important pest of natural pasture over a large area of Namaqualand. Mesembryanthemums form a major constituent of the pasture in the affected area and are of particular importance as the only green feed available to sheep during summer. Attacked plants are often completely defoliated and are then unable to survive the summer drought. Epidemic outbreaks of the pest occurred during 1959, 1964, 1965 and 1970 (Walters, Walters & Lowrens, in press).

The specific identity of the pest is as yet uncertain. It has been identified as *Mesocelis montana* Cramer (Ac. U.S. 1330*), but differs so widely from the latter in size and biology that a final opinion must be reserved until more intensive taxonomic investigations can cast light on the subject.

The biology of *Mesocelis* sp. is described by Walters *et al.* (in press). Data on closely related *Mesocelis* spp. have been presented by Hesse (1935) and Taylor (1950). The mesembryanthemum caterpillar is well adapted to survive the dry climate of its habitat. The extremely dry summer is bridged in the form of aestivating eggs which are laid during the period October to November. These eggs hatch in the following June or July when favourable moisture conditions are created by seasonal rain. The eggs thus take from seven to nine months to complete their development. The larvae occur during the period June to October. There are six larval instars and the fully grown larvae attain a length of from 70 to 90 mm. They are covered with long hairs which may be irritating to susceptible humans. The larvae are highly active, migrating from plant to plant, and this activity reaches a peak in the final instar when long distances may be covered in their search for suitable pupation sites. The active larvae provide the only mechanism for the natural distribution of the species as the female moth is incapable of flight.

Male and female larvae differ in their choice of sites for pupation. Female larvae seek well-protected sites under large rocks, in small caves and underground in rodent tunnels, while male larvae will

* Accessions Collection University of Stellenbosch.

also pupate under small stones, paper and litter on the soil surface. Pupation takes place within a tough parchment-like cocoon, at one end of which a weak spot occurs which is utilized for escape of the moth in the case of males and for copulation in the case of the female. The male pupa is typically lepidopteran in appearance with well-defined wing-pads and appendages. The female pupa however bears no sign of wing-pads and the appendages are extremely reduced. The pupal stage lasts from four to five weeks so that moths put in an appearance from the end of September to November.

The female moth never leaves the cocoon and her activities are confined to mating and oviposition. She is degenerate and sac-like in appearance. The male is normal in appearance and although not a strong flyer is very active at night in his search for the females in their well-protected pupation sites. After mating, the female lays as many as 200 eggs within her cocoon. These eggs pass the summer within the cocoon and are protected from unfavourable conditions by a thick mass of insulating hair which is rubbed off by the female, the tough parchment-like wall of the cocoon, and the sheltered site chosen for pupation.

Many natural enemies, both predaceous and parasitic, attack the post-embryonic stages of the pest and appear to exert a considerable influence on pest numbers in non-epidemic years. A "wilt" disease has also been observed to occur in larval populations.

The fact that fully grown larvae, especially females, tend to congregate in areas where rock formations appear above ground and suitable pupation sites are therefore readily available, may provide opportunities for the application of mechanical and chemical control methods. The pupation sites can be uncovered and pupae, moths and eggs can be destroyed. Chemical control methods should be practicable if applied shortly after the hatching of the larvae in winter when they are still concentrated near female pupation sites. The use of chemicals, however, should only follow careful research into possible side effects on the natural enemy complex which appears to play an important part in limiting pest numbers.

B. *Pests of Improved Pastures*

(i) The lucerne caterpillar, Colias electo L. (Lepidoptera: Pieridae)

The lucerne caterpillar is the most widespread and probably the most destructive pest of lucerne in southern Africa and closely allied to the *Colias* species attacking lucerne in other regions of the world. *Colias electo* is generally regarded as including all those forms occurring in Africa, southern Europe, western Asia, India, Burma, Tibet and China (Van Son, 1949; Pinhey, 1965) although Jarvis (1953) persists in granting species status to the European form known as *P. croceus*.

The South African form of *C. electo* is the nominotypical one and was first described by Linnaeus in 1763 as *Papilio electo*. This species name remains the valid one although some confusion was caused by a subsequent reference by Linnaeus to the insect as *Papilio electra*.

The earliest record of the pest attacking lucerne in South Africa was in 1896 (Louensbury, 1896), at a time when lucerne cultivation was rapidly expanding as a result of the ostrich boom. Emphasis was at first laid upon the devising of control methods against the pest and the study of its biology was neglected. Smit (1936) gave a short description of the life history of the pest and pointed out that seven generations per year could be completed. An unpublished work by De Wet (1951) involved a detailed study of the biology of *C. electo* and of its parasite, *Pteromalus puparum*. The influence of environmental factors, especially temperature, on the development and viability of the immature stages was determined, as well as on the behaviour, fecundity and longevity of the imagines. The threshold temperature for the initiation of pupal development was found to be higher than that for the earlier stages with the result that it was possible for low external temperatures to induce a state of virtual hibernation. Adult activity, especially copulation, was found to be correlated with the occurrence of periods of sunshine so that long periods of cloudy weather could lead to a serious reduction of breeding and other activities, such conditions being common in the western Cape during midwinter. This worker concluded that a total of 6,2 generations per year could be completed under Cape Peninsula conditions. Field observations showed that new lucerne growth shortly after cutting was favoured as a site for oviposition above other stages of growth, flowering lucerne being rejected. These observations accord well with those of Hovanitz (1944a, 1944b) on the alfalfa caterpillar (*Colias eurytheme*) which he reported as laying eggs only on lucerne growth below 30 cm in height. De Wet (1951) found this behaviour to be restricted to lucerne as *C. electo* would oviposit on *Trifolium repens* and other hosts at any stage of development. Smithers (1960), in his work on *C. electo* in Rhodesia, confirmed the findings of De Wet on the biology of the pest, especially with regard to the preference shown for young lucerne growth for oviposition and that bright sunshine was a prerequisite for copulation. He also noted that larval migration was limited as no noticeable movement of large larvae from old lucerne to new growth was observed. Larval density was found to reach a peak at four to five weeks after cutting, i.e. when larvae from eggs laid on young growth were approaching maturity. The correlation of oviposition with the growth stage of lucerne was seen as causing great variation in the succession of generations of the pest within different fields in the same locality, succession being synchronized with the development of the crop.

The earliest recommendation for the control of the pest was the premature cutting or grazing of the crop, with the limiting of possible migration by the erection of mechanical barriers and the spraying of unmowed border strips with arsenicals (Lounsbury, 1906). Later workers recommended the creation of conditions conducive to the outbreaks of polyhedral virus disease in larval populations by the heavy irrigation of infested fields accompanied by harrowing or the dragging of bushes (Lounsbury, 1913; Anon., 1931; Smit, 1936). The prevalence of polyhedral virus disease in *C. electo* populations attracted much interest, Lounsbury (1913) describing attempts to artificially induce epidemics by the spraying of extracts of diseased larvae. Although Lounsbury concluded that such attempts to artificially distribute the disease were ineffectual due to the virus being endemic in all areas infested by the pest, Anon. (1931) persisted in recommending the spraying of an extract from diseased larvae. Steinhaus (1948), in

his work on a similar disease found in *C. eurytheme*, found that the causative agent was present in areas occupied by the pest and could be found in topsoil, stubble and surface debris in such localities. Drought was also found to have little detrimental effect on the persistence of the disease. These findings supported Lounsbury's contention that the virus was omnipresent in *C. electo*-infested areas. Steinhaus & Thompson (1949) however showed that the disease could be induced in *C. eurytheme* at larval densities lower than those at which it would normally appear, by the spraying of an infected larval extract, thus inducing it at an earlier date than that at which it would normally evince itself. De Wet (1951) also paid attention to this disease in *C. electo* and concluded that population density and not temperature or humidity was the most important factor in inducing the outbreak of polyhedrosis under normal conditions in nature.

De Wet found several birds and insects to be enemies of *C. electo Pteromalus puparum* L. (Hymenotera: Pteromalidae) was regarded as the most important of the six parasites encountered. Special attention was devoted to the study of this species and De Wet concluded that artificial increase of this pupal parasite for release at critical stages in the seasonal history of *C. electo*, such as late winter when fully grown larvae and pupae form the majority of the population, might lead to substantial reduction of summer populations of the pest. The ease with which *P. puparum* could be increased in captivity and the long oviposition period, recommended it for use as a control agent.

The use of chemicals for the control of the pest has also attracted attention. The arsenicals were unsuitable for general use on lucerne and the earliest general recommendation of an insecticide for *Colias* control was that of Anderssen (1947) who advocated the use of cryolite as a dust treatment. Anderssen (1954) also recommended the use of cryolite as a spray treatment when windy conditions made dusting impracticable. At the present time several synthetics are used to control the pest, Bot, Findlay & Hollings (1970) recommend carbaryl, endosulfan, mercaptothion and trichlorfon as being effective against the pest in the form of dusts and sprays.

(ii) The black sand mite, Halotydeus destructor **(Tucker) (Acarina: Eupodidae)**

Halotydeus destructor is indigenous to the western Cape and was first recorded as a threat to pastures and a wide variety of crops by Jack (1908). It was described by Tucker (1925) as *Penthaleus destructor* but was later assigned to the genus *Halotydeus* by Womersley (1933).

It is of general occurrence in the Winter Rainfall Region and has been recovered from Bitterfontein in Namaqualand and as far east as George. The first record of its occurrence in Australia was by Newman (1923). According to Swan (1934) it can be found in Tasmania, Victoria, New South Wales, A. C. T. and South and Western Australia.

Jack (1908) remarked on the sensitivity of the pest to dry conditions and noted that the destructive period was restricted to the period June to October with numbers decreasing rapidly with the onset of summer conditions. Several generations could be completed within this period as development from oviposition to attainment of the adult stage lasted only 31 days at room temperature. The fact that the egg provided the vehicle for the bridging of summer conditions and that all active stages disappeared with the onset of such conditions was first noted by Tucker (1925). In the field these eggs hatch when favourable moisture conditions are ushered in by the autumn rains. The winter eggs are laid on the undersides of leaves and usually hatch within eight days. Tucker (1925) remarked that fertilization did not appear to be essential for egg development and several cases of apparent parthenogenesis were noted. No records of males occurring in field populations were made by Tucker or subsequent workers (Womersley, 1933, Meyer & Ryke, 1960), and it therefore seems probable that parthenogenesis is the general form of reproduction in this species.

The black sand mite has also received considerable attention from Australian workers. Swan (1934) found that winter eggs needed continuous contact with free water to complete normal development and hatch. Solomon (1937a) recognized the dependence of the pest on high humidity conditions for survival as well as the sensitivity of the active stages to high temperatures. In a separate study (1937b) he observed the tendency of eggs to accumulate within the body towards the end of the rainy season without oviposition taking place. Norris (1938) concluded that three generations were completed during the wet season in western Australia. Pronounced overlapping of generations occurred, especially later in the season. In 1950 Norris demonstrated that distinct differences occurred between the aestivating eggs, which accumulated in the bodies of mites with the advent of warm dry weather, and the ordinary winter eggs. The former were larger and had thicker chorions than the latter, and could survive dry storage for as long as four years. A minimum period of exposure to summer conditions is required before normal development can proceed in aestivating eggs, thus preventing premature hatching in response to summer rains, and subsequent destruction due to drought. This egg diapause was regarded as a special adaptation to the mediterranean-type climate.

Investigations by Norris (194[illegible], 1948) demonstrated the importance of mite attack with regard to pasture yield, and indicated that the greatest reduction in subterranean clover yield was caused by mite attack occurring during the first few weeks after germination in autumn.

No efficient natural enemies of the black sand mite have been found within the areas occupied by the pest. A predatory mite, *Anystis* sp., which preys on the related eupodid, *Penthaleus major*, has however been imported into western Australia and South Africa (Walters, 1970) from France in the expectation that it will prove of value against the sand mite.

Early recommendations for the control of *H. destructor* were based on cultural practices and the use of tobacco-based dusts and sprays (Jack, 1908; Tucker, 1925). Tucker also found rotenone and lime sulphur to be effective spray materials against the pest. Cresol-based sprays were found to be effective by Newman (1930) and Norris (1943). Norris also found that good control could be obtained with sweetened sodium arsenate-based baits using chaff as a carrier.

DDT was found to be most effective against the mite, both when applied as an autumn top-dressing combined with superphosphate and as a spray treatment (Jenkins, 1956). Wallace (1957b) found that DDT-superphosphate topdressing, when applied by seed drill in late summer at a rate of 2,2 kg of DDT per hectare, had a controlling effect which was still evident during the second winter following treatment. Joubert (1952) recommended the use of DDT as a spray or dust treatment for use on vegetables and established pastures, while BHC was recommended for use on flowers and when establishing pastures.

The sand mite often occurs in association with the lucerne springtail (*Sminthurus viridis*) in both Australia and South Africa and DDT has been combined with mercaptothion (Jenkins, 1956) and with azinphos-methyl (Walters, 1966) to provide control of both pests in a single treatment. Endosulfan was recommended by Walters (1970) for use against the mite on DDT-sensitive cucurbits and on established pastures.

Seed treatment with systemic insecticides, in particular dimethoate, for the subsequent protection of legume seedlings from mite attack was recommended by Wallace (1960). Jenkins (1964) did not approve of this practice where virgin soil was being sown and field sources of *Rhizobium* bacteria were not available, as organophosphorus materials were known to adversely affect the bacteria used to inoculate treated seed. Walters (1966) pointed out that although dimethoate treatment appeared to have a depressing effect on nodule formation during the first few weeks after germination, this effect disappeared after six weeks when nodule formation was comparable to that on untreated seedlings. Figures were presented by Walters (1970) showing that seed treatment with dimethoate and disolfoton results in lucerne seedlings remaining toxic to *H. destructor* for 55 days after emergence.

(iii) The white-fringed beetle, Graphognathus leucoloma **Boh. (Coleoptera: Curculionidae)**

The white-fringed beetle originated in South America but has become a serious pest in several regions of the world into which it has been introduced, including the United States and Australia (Joubert, 1951) and New Zealand (Todd, 1968). According to Joubert (1951) the earliest record of its occurrence in South Africa was from Rosebank, Cape in 1941 (Ac. U.S. 601)*. It has subsequently been recorded from Stellenbosch (1946), Vredendal (1949), Koekenaap (1951), Robertson (1957) and Beaufort West (1962).

The adults are incapable of flight but the species is nevertheless easily distributed in all stages of development (Joubert, 1951; Anon., 1956); larvae and pupae in soil and nursery stock, eggs in hay and on plants and the adults by clinging to produce and implements or carried in irrigation water. The beetle is parthenogenetic, no males having ever been discovered, and this fact considerably facilitates rapid distribution of the species. Its wide distribution range in its countries of origin (Berry, 1947) and the large area already colonized in the United States, indicate that this insect should extend its distribution in this country and become more important, especially in our existing and planned irrigation areas.

The biology of *G. leucoloma* was described by Joubert (1951) who stated that one generation is completed per annum. He was, however, of the opinion that some individuals, as was also the case in the United States, developed more slowly than others and completed one generation in two years. According to Berry (1947) similar observations were made in South America where one generation per year occurs in the warmer northern area of the distribution of the pest and only every two years in the colder southern area. Joubert (1951) comments on the longevity of the adults, some of which may live for as long as five months, during which time as many as 1 000 eggs may be laid. The eggs are laid in clusters of 12 to 60 on various parts of plants, and other objects where these touch the soil surface. The incubation period varies from 17 to 30 days but contact with free water is necessary for hatching to take place. In the absence of free moisture, the eggs will, however, remain viable for several months. The subterranean larvae attack the roots of plants and although they may penetrate as deep as 60 cm below the surface they are usually concentrated in the upper 23 cm. Larval development usually takes place during the winter months, these larvae arising from eggs laid during the summer and attaining the adult stage during the following summer. In cases where one generation is completed in two years, the larval development will extend over two winters and the intervening summer. The pupal stage lasts about two weeks and is completed in a pupal cell which is constructed about 15 cm below the soil surface. The adults are most common during summer when the aerial parts of plants are attacked but may persist until as late as July. This agrees closely with the data presented by Berry (1947) for the pest as occurring in South America.

Lucerne is the crop which has proved most vulnerable to the pest in South Africa. The potential of this pest is, however, very great as over 400 plant species have been listed as hosts in the United States, of these only a small number have as yet suffered damage in this country (Joubert, 1951). Graminaceous plants are not favoured and depress fecundity.

The pest may be controlled by both cultural and chemical methods. The rotation of legumes with less favoured food plants such as cereals, and the establishment of lucerne on pest-free soil only was recommended by Joubert (1951). He also recommended clean cultivation and ploughing during summer in order to destroy the larvae. According to Joubert (1951) increasing the organic content of infested soils leads to a reduction in pest damage. Joubert (1954) recognized the rôle that birds and poultry could play in the destruction of the adults and proposed a specific crop rotation programme for the controlling of the pest.

Chemical control methods have proved very successful against this insect. DDT was recommended by Joubert (1951) as foliar dust or spray treatments against adult beetles, and as a soil treatment against the larvae at a rate of 9 kg of active material per ha harrowed into the upper 10 cm of soil. Cryolite was also regarded by him as being effective against adults. Joubert (1954) pointed out that soil fumigation with EDB or DD against

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nematodes would also control *Graphognathus* larvae, but was too costly to use against the latter pest only. He recommended soil treatment with aldrin at 1,25 kg of active material per ha, applied as a mixture with 500 kg of moist sand per ha, broadcast over the area to be treated and harrowed into the upper 10 cm of soil. In the United States Anon. (1956) regarded treatment of the upper 10 cm of soil with any one of aldrin, dieldrin, chlordane, DDT or heptachlor as giving effective long-term control of the larvae. Walters (1961) found that soil treatment with aldrin and dieldrin at 1,25 kg, chlordane at 4,2 kg and DDT at 8,4 kg of active material per ha still gave significant control of the pest five years after application.

At present this pest is adequately controlled in practice by the use of aldrin as recommended by Joubert (1954). The current popular antogonism to the use of persistent insecticides may, if pushed as far as total elimination of their use, however give rise to serious control problems with regard to *G. leucoloma*. Todd (1968) tested 38 insecticides for toxicity and found only six to be toxic to the larvae, these six including the persistent chlorinated hydrocarbons i.e. dieldrin, lindane, and heptachlor. As long-term persistence is a prerequisite for economic control of the pest in lucerne, an early search for alternative control methods is to be recommended.

(iv) **The lesser army worm,** Spodoptera exigua **(Hbn.) (Lepidoptera: Noctuidae)**

The lesser army worm is recognized by Bot *et al.* (1970) as a pest of ornamentals, vegetables and wheat in South Africa. It may also cause serious loss to lucerne growers and in the western Cape is a recognized pest of natural pastures.

It was originally described as *Noctua exigua* by Hübner in 1808 but in 1852 was designated the type species of the genus *Laphygma* by Guenée. At the present time it is generally assigned to the genus *Spodoptera* [Boursin, 1963, Bot *et al.* (1970)].

Spodoptera exigua has a cosmopolitan distribution (Hampson, 1909, Janse, 1939) and attacks a wide variety of cultivated and other plants (Wilson, 1934), Taylor & Haines, 1930, Lourens, 1966a). In 1913 it was first recorded as causing serious damage to lucerne and grass in South Africa (Anon., 1913).

In the winter rainfall region epidemic outbreaks of the pest under dryland conditions coincide with the emergence of cereals and self-sown grazing after the start of the winter rains (Lourens, 1966a). During such outbreaks extensive damage to lupins may also occur. The pest is omnipresent in small numbers on lucerne during the summer, but may on occasion occur in such numbers as to cause extensive losses.

The biology of the pest on cotton was described by Brain (1918). The young larvae were found to feed gregariously under a loosely spun web on the undersides of leaves. At a later stage they took refuge in the soil or under surface debris during the day and fed only at night. Larval development lasted 10 to 14 days during summer and was terminated by pupation in a prepared cell beneath the soil surface. The pupal stage lasted from one to two weeks under summer conditions but was considerably extended under winter temperatures. Several generations were possible during a single year. This knowledge was further amplified by Taylor (1931) who presented data on egg and larval development as well as on adult behaviour and oviposition. The findings of Brian and Taylor were in general agreement with those of Wilson (1934) working on the pest in Florida. According to Wilson development was continuous throughout the year in Florida although population density was at its lowest during winter.

Following an examination of the influence of population density on the appearance of larvae, Faure (1943) postulated the existence of three larval forms or "phases", viz. *solitaria, transiens* and *gregaria,* analogous to those occurring in migratory locusts. The darker colour which was characteristic of mass-reared or *gregaria* larvae was ascribed to an increased storage of waste products as a result of heightened activity. Lourens (1966a) states that the larvae comprising the epidemic outbreaks which occur during autumn (March-June) in the Winter Rainfall Region are of the *gregaria* or "commando" type while the green "solitaria" form predominates during summer. He concluded that epidemic outbreaks originate on stubble fields and that migration of larvae to neighbouring cultivations takes place as soon as the food supply is exhausted. He further states that development of the pest is continuous throughout the year, four to five generations occurring per annum with considerable overlapping of generations taking place.

The adults are strong flyers so that outbreaks may follow the immigration of moths from localities far removed from the point of outbreak (Faure, 1943; Williams, 1958). Effective control measures are thus dependent on early observation of moth activity or young larvae.

An early recommendation for the control of the pest in lucerne was the use of a paris green bait with bran as the carrier (Anon., 1913). Dusting or spraying with arsenicals was recommended by Brain (1918) for use on cotton while Taylor & Haines (1930) regarded sodium arsenite as an effective spray material for the destruction of larvae which collect in furrows drawn across their path of migration. Dusting with calcium arsenate was recommended for use on peas by Anon. (1943). Maize meal baits in which trichlorfon or DDT was used were successful in protecting young lucerne in the eastern Cape (Anon., 1967) while both materials also gave good results when applied as dusts or sprays. Bot *et al.* (1970) recommend the use of mercaptothion or DDT for the protection of ornamentals, wheat and vegetables, while nendrin should be applied only to ornamentals and wheat.

A wide variety of parasites and other natural enemies of *S. exigua* have been recorded and are reviewed by Lourens (1966b). A braconid parasite was found to be responsible for very high mortality rates among larvae during summer in the Winter Rainfall Region. Taylor & Haines (1930) found tachnid and chalcid parasites to attack the pest in the eastern Transvaal.

(v) **The lucerne springtail,** Sminthurus viridis **(L) (Collembola: Sminthuridae)**

Smithurus viridis is the most important pest of dryland lucerne and clover pastures in the western Cape. It enjoys a similar pest status in the mediterranean climatic regions of Australia (Davidson, 1934) and in New Zealand (Dumbleton, 1938). In the palaearctic region where the pest originated and in which it is widely distributed it is, however, of no economic importance.

Walters (1968) is of the opinion that *S. viridis* was introduced into South Africa in the form of eggs present in subterranean clover seed imported from western Australia during the period 1939 to 1941. In 1941 the pest was found attacking oats near Somerset West (Ac. U.S. 251*) and by 1954 had established itself in the Caledon district. At present it is widely distributed from the Cape Peninsula in the west to the Bredasdorp district in the east.

The study of the biology of *S. viridis* has received particular attention from Australian workers. Holdaway (1927) remarked upon the discontinuous seasonal cycle of the pest, the dry summer being bridged in the form of drought-resistant aestivating eggs. Davidson (1934) in turn conducted careful studies of the factors influencing egg development as well as those influencing postembryonic development and distribution. MacLagan (1932) studied this species in England but Walters (1968) found his results to be of little application to the situation in South Africa.

Walters (1968) studied the biology of the pest under local conditions. He found that postembryonic development in *S. viridis* is epimetabolic, as found in other symphypleonid springtails by Agrell (1949), and that distinct differences in size and development occurred between the sexes. Fecundity was affected by temperature, host plant species and the reaction of the soil substrate. A soil reaction of pH 6,3 and a temperature of 15,5 °C were found to be the most favourable. Postembryonic development was accelerated by increases in temperature up to 25 °C after which further increase became harmful. Short daily exposures to temperatures as high as 35 °C were, however, without harmful effect, indicating that the active stages could survive summer temperatures if favourable moisture conditions were maintained.

Walters (1968) also found that the number of eggs produced per individual was depressed by increase in population density. The presence of other arthropods was shown to exert the same influence as an increased density of springtails, indicating that an intrinsic density-governing mechanism was not concerned. The phenomenon was ascribed to increasing disturbance of ovipositing females with increasing population density, resulting in an increasing failure of females to cover their egg batches with a protective layer of soil. A density-governing reaction, perhaps related to the above, was observed in field populations by Wallace (1957a) and was ascribed by Wallace (1967) to the increasing storage at high densities of waste products such as uric acid in the body. The latter caused early deaths of adults and increased mortality of young nymphs feeding on the dead bodies of adults.

The pest does not occur in very sandy areas such as the Cape Flats and is most destructive on heavier soils. This was ascribed by Walters (1968) to the interaction of soil texture with moisture, thus influencing the survival of eggs and nymphs. Contact with free water is essential for the completion of egg development although too much water could retard development. Under field conditions a shortage of free water in spring leads to a "banking up" in the soil of eggs at an advanced stage of development, as oviposition continues for some time after hatching has ceased. Eggs remaining dry in the field or in the laboratory were able to survive exposure to temperatures far higher than those found to be lethal to eggs under moist conditions. The egg stage is thus well adapted to survive summer conditions.

According to Walters (1968) four to five generations per active season can be completed under dryland conditions, depending upon the length of time over which moisture conditions remain favourable. Much overlapping of generations occurs as a result of pronounced variation in the incubation period of eggs laid at the same time and the long period of time over which females are able to lay eggs. Population density and composition are thus more a reflection of the occurrence of favourable conditions than of the periodicity of occurrence of different generations. The highest population density usually follows the hatching of the aestivating eggs in autumn while the lowest densities occur during midwinter when unfavourable cold and very wet conditions prevail. The active stages are restricted to the rainy season under dryland conditions. The fact that the pest could persist throughout the year under irrigated conditions was regarded as indicating the absence of a definite diapause in the aestivating egg. Eggs laid in midwinter were found to be highly resistant to dry conditions although not destined for aestivation under normal circumstances, thus indicating that a diapause mechanism need not be essential for survival of the summer. Wallace (1968) presented evidence however which indicated that certain eggs laid at the end of the active season require a minimum exposure to summer conditions before being able to complete normal development. This condition he regarded as being induced by the maturing of the host plants in spring. The inhibitory effect of this suspected diapause could also be broken by the breaking up of the egg batches.

Various chemicals have been used as spray treatments against *S. viridis*. Lime-sulphur was recommended by Davidson (1933). DDT was ineffective and led to an increase in pest numbers through destruction of natural enemies (Wallace, 1954). Mercaptothion was recommended by Jenkins (1956) and Nel (1959). Walters (1966) recommended azinphos-methyl as an alternative to mercaptothion because of its longer residual effect even when applied at 36 g of active material per ha as opposed to mercaptothion at 72 g. Spray treatments should be applied during autumn when maximum population densities occur and result in losses in grazing potential and in stand of annual clovers.

The use of systemic insecticides for the treatment of legume seed for the protection of seedlings against attack by *S. viridis* and *Halotydeus destructor* was first recommended by Wallace (1960) and subsequently in South Africa by Walters (1966). The latter remarked upon the retarding effect of seed treatment with dimethoate upon the nodulation of lucerne seedlings by *Rhizobium* bacteria. This practice is widely employed at present for the establishment of lucerne-clover pastures.

Womersley (1933) remarked upon the control exerted upon *S. viridis* by the bdellid mite, *Bdellodes lapidaria* Kramer, a predator imported by chance into Australia from Europe. Further evidence of this biological control effect was presented by Wallace (1954). This predator was imported into South Africa during the period 1963 to 1965 and has

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been successfully established in three different localities (Walters, 1969). During 1969 a second bdellid mite, *Neomolgus capillatus* Kramer, was introduced into South Africa and Australia from France and Morocco as part of a co-operative project with the C.S.I.R.O. of Australia. At the present time *N. capillatus* has been successfully established in both countries of introduction.

C. Miscellaneous Pests

Pastures often suffer damage through attacks by insects better known as pests of other cultivated crops, while the wide range of ecological situations and the continued evolution of agricultural practices lead to the regular emergence of hitherto unknown pests and the increase in importance of others formerly regarded as innocuous.

The clover moth (*Nomophila noctuella* Schiff.) (Lepidoptera: Pyralidae) attracted attention during 1969 when it was collected near Stormsrivier. The larvae destroyed the aerial parts of *Trifolium repens*. Although known from other parts of the globe (U.S.A., Bulgaria, Yogoslavia), the pest has received no real attention in South Africa. The present swift increase in the areas under established lucerne clover pastures might, however, lead to its becoming troublesome. The bionomics of the pest have been studied by Popova (1966) and Felt (1893).

Epilachna similis Thunb. (Coleoptera: Coccinellidae), the grain ladybird, is a major pest of cereals in the Winter Rainfall Region. The insects are not restricted to cereals, but various pasture grasses and maize intended for ensilage may be severely damaged. Lourens, 1966b, studied the biology of the insect in the western Cape Province.

The introduced snails, *Theba pisana* Müller and *Cochlicella ventricosa* Draparnaud, are pests of established and natural pastures in the coastal regions of the western Cape. Dürr (1964) studied the bionomics of *T. pisana* while Joubert, 1945 and Joubert & Walters (1951) discuss control measures.

The American bollworm *Helicoverpa (Heliothis) armigera armigera* (Lepidoptera: Noctuidae) is a sporadic and sometimes serious pest of lupins in the western Province. Lupins are attacked during spring and in some years very serious losses may be suffered. Nel (1957) recommended the use of either DDT or nendrin as aerial spray treatment for the control of the pest on lupins. Bot *et al.* (1970) restrict their recommendations to the use of DDT as an aerial or low volume spray treatment. The seasonal history of the pest on lupins was discussed by Nel (1961). Four generations of the pest occur per annum in the higher rainfall southern areas of the Western Province. In the lower rainfall northern areas such as Graafwater and Klawer one generation and a partial second generation occur on lupins during spring. Host plants are absent during the summer in the drier areas and continuity of reproduction is thus not possible there. Nel (1961) regarded the serious infestations which occur in the drier areas as being initiated by immigrant moths which originate in the higher rainfall southern districts.

The pink maize stalk border *(Sesamia calamistis* Hmps) (Lepidoptera: Noctuidae) sometimes attacks pasture grasses, sorghums and maize intended for ensilage. The biology of this pest and its control in sweet corn was discussed by Van Heerden, Walters & Walters (1967). The low economic potential of pastures does not, however, warrant the implementation of intensive control programmes such as are required for sweet corn cultivation.

Self-sown grazing in stubble fields is of great importance for wool production in the sandy wheat-growing areas along the lower reaches of the Berg River. Large scale destruction of such grazing may be brought about by the attacks of the caterpillars of the ghost moth (*Metahepialus xenoctenis*) (Lepidoptera: Hepialidae) in certain years. The pest has to date received little attention as a pasture pest, but is easily controlled in wheat cultivations by aerial spraying with DDT.

The clover beetle *(Luperodes nigricollis* Bryant) (Coleoptera: Calerucidae) occurs as a sporadic pest of *Trifolium repens* pastures in the eastern districts of the Winter Rainfall Region from Swellendam to Humansdorp. Outbreaks of this pest are very limited with regard to the size of the area affected and it is of little economic significance at present. The continuing expansion of the area under clover pastures in this region should, however, lead to the increasing importance of this species and to more intensive study of its biology and control.

The armyworm [*Spodoptera exempta* (Walk.)] (Lepidoptera: Noctuidae) may cause widespread damage to natural pasture in the northern provinces of South Africa. Its biology and ecology were studied by Hattingh (1941).

OPSOMMING

PLAE OP WEIVELDE

Die natuurlike weiveld van Suid-Afrika is al dikwels beskryf as die land se grootste landboukundige bate. Enige insek wat die weiveld bedreig, moet in 'n baie ernstige lig gesien word. Die saak word verder, gekompliseer deur die feit dat die meeste van ons weiveldplae veroorsaak word deur een of ander vorm van ekologiese versteuring.

Aangeplante weidings in die vogtiger dele van die land, of onder besproeiing, speel ook 'n lewensbelangrike rol in die diere-industrie van Suid-Afrika en ook hier moet deeglik rekening gehou word met insekplae. Hierdie plae wissel van 'n primitiewe insek soos die lusernerdvlooi tot by 'n gespesialiseerde kewer soos Graphognathus leucoloma.

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